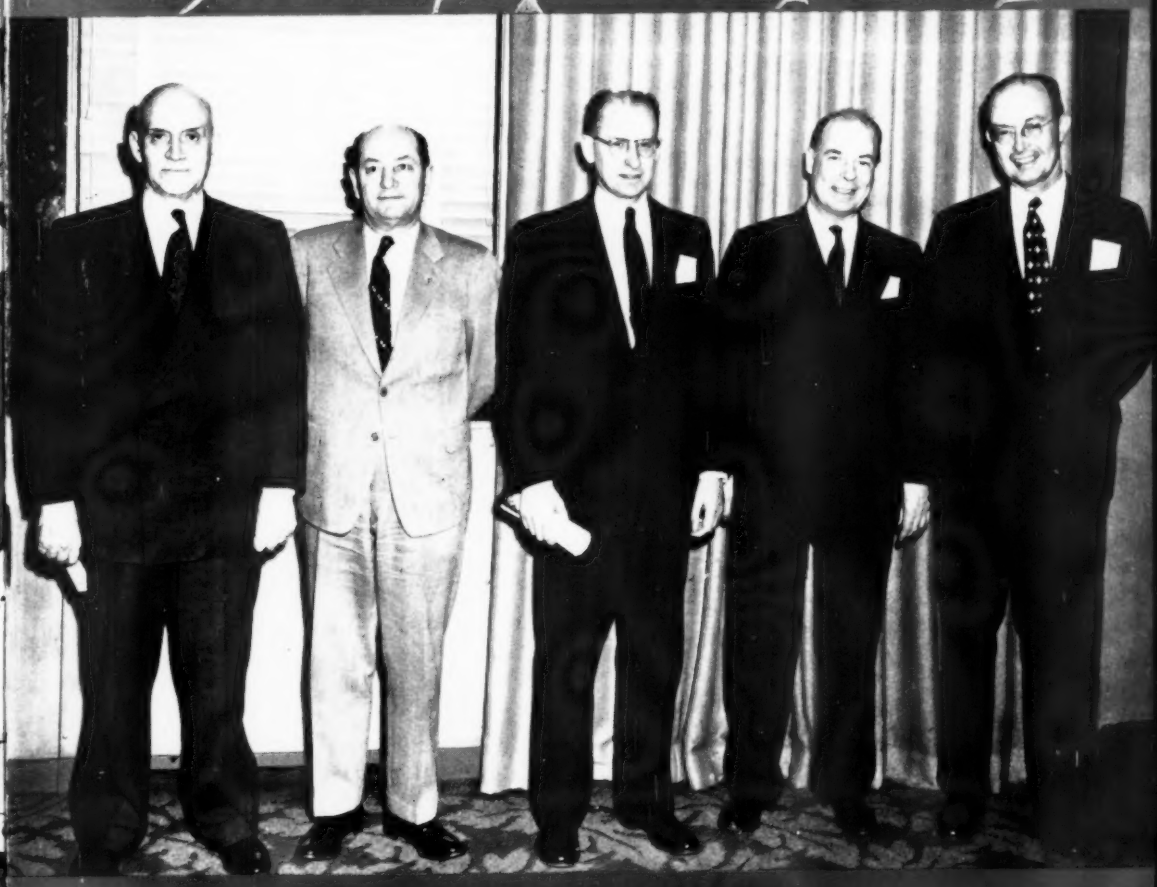
Weatherwise



Volume 9, Number 3 June 1956

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE"—BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

DAVID M. LUDLUM, *Editor* HENRY W. BULKLEY, *Associate Editor*

AMS CALENDAR — 1956–57

Seattle, Washington	12–14 June
Boulder, Colorado (Conference on Solar-Weather Relationships)	25–27 July
Albuquerque, New Mexico	5–7 September
Asheville, North Carolina (Conference on Climatology)	29 October–1 November
New York City, New York	28–31 January
Chicago, Illinois	March
Cambridge, Massachusetts (Sixth Weather Radar Conference)	26–28 March

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Cover: Five presidents of the AMS attend the New York meeting in January. From left to right: Dr. F. W. Reichelderfer 1940–41, Capt. H. T. Orville 1948–49, Dr. H. R. Byers 1952–53, Col. A. H. Merewether 1954–55, and Dr. R. D. Fletcher 1956–57.

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Dr. George Cressman, JNWP director, studying numerical display. IBM photo.

Organization and Operation of the Joint Numerical Weather Prediction Unit

EDWIN B. FAWCETT; LCDR. WILLIAM E. HUBERT, USN;
AND LCDR. ALBERT L. STICKLES, II, USN

INTRODUCTION

ON the first of July 1954 a group of 15 meteorologists gathered at the Central Office of the Weather Bureau in Washington, D. C. They were the nucleus of the Joint Numerical Weather Prediction Unit. The Weather Bureau, Naval Aerological Service, and Air Weather Service of the Air Force had decided to combine forces in a revolutionary approach to forecasting. Much research work had already been done in this country and abroad on numerical weather prediction using high-speed electronic computers developed during and since World War II.* The time had arrived to put the experimental techniques into practice. It was felt that a great deal could be learned by utilizing the new methods on a daily operational basis.

The beginning of the new Unit was humble indeed. The Weather Bureau very kindly provided four rooms in the Annex at its Central Office pending completion of new quarters at Suitland, Maryland. The IBM Type

* Several successful numerical forecasts were made at the Princeton Institute for Advanced Study under the sponsorship of the Office of Naval Research.

Capt. William Steshko, USAF, checks the 100 mb chart for data coverage. IBM photo.

701 Electronic Computer was not to be delivered until Spring of 1955; however, much valuable preliminary work was completed during the initial period of organization. IBM supplied an expert to teach the art of "coding" or writing instructions for the computer, and most of the Unit's personnel took this course during the Summer of 1954. In addition, most of the research work already accomplished in numerical prediction was surveyed, and weather data to test four different atmospheric "models" (sets of mathematical predicting equations) were readied. Arrangements were made to use the IBM 701 computer in New York City to run these tests. One of these models of the atmosphere was then selected for producing the daily forecast charts.

The new quarters at Suitland were ready for occupancy early in December 1954. IBM delivered the computer during the first week of March 1955, and by the middle of April the first experimental forecast charts were issued. The official opening ceremonies were held on 6 May 1955. Since then the JNWP Unit has been producing daily forecast weather charts at three levels in the atmosphere based on two different atmospheric models.

The first of these yields forecast charts of pressure patterns at a level near the earth's surface (1,000 mb), at 10,000 feet (700 mb), and at 20,000 feet (500 mb) in the upper atmosphere. These forecasts are made for periods 12, 24, and 36 hours in advance and cover North America and the surrounding oceans. A second model yields forecast charts of pressure patterns at 20,000 feet only (500 mb) for periods 24, 48, and 72 hours in advance for about two-thirds of the Northern Hemisphere. These forecast charts are disseminated for use by meteorologists of the three sponsoring weather services which contribute money and personnel to the Unit. They are used as an aid in arriving at the final forecasts used within each Service, and thus indirectly affect the forecasts issued to the public.

Organization

From its inception the JNWP Unit has been divided into three major sections—Analysis, Computation, and Development. Their duties are data processing, translation to and from computer language, and improvement of numerical predicting techniques. All are under the over-all control of the Unit's Director, Dr. George P. Cressman. Since the beginning of the numerical unit, the number of personnel has slowly

grown from the original nucleus of 15 to a total of 48.

The Development Section adapts theoretical principles of numerical prediction (as established by basic research) into operational models of the atmosphere. It refines computational techniques and extends models in both area and time. It also verifies the results obtained from the various models in order to measure their usefulness, study their underlying assumptions on a controlled basis and finally to improve them.

The Computation Section, with its knowledge of machine logic and automatic computation, adapts the equations to machine language. This process provides for the introduction of weather data into the machine together with the numerical language codes needed to obtain the forecast solution. The resulting solution is then translated into a form which can be used to aid forecasters in the field as well as further research work.

The primary purpose of the Analysis Section is to provide the initial pressure-height data needed to start the daily numerical forecasts. These data are provided at fixed locations, or grid points, equi-spaced over the area for which the forecast is to be made. Each day the electronic computer makes the analysis over North America and surrounding oceans at the 1,000 mb, 700 mb, and 400 mb pressure levels. To accomplish this, it uses 1500Z radiosonde and pilot balloon reports which have been listed separately by hand from the original teletype data at the three levels and punched on IBM cards. It also uses extra information, over ocean areas, which is provided by the analyst and then punched on IBM cards. Thus, the analysis effort is concentrated over ocean areas where the analysts are primarily responsible for providing the input data. At the same time, the analysts must monitor the North American area to check for incorrect and garbled reports. The machine analysis program is designed to eliminate large errors in data. However, the analysts seek to keep the data errors to a minimum. After the machine has accomplished its analysis at each of the three levels, the analyst must examine them to see that they conform to the original data. When each of the three analyses has been carefully checked, then the forecast begins. The forecasts come off the Electronic Computer with the pressure pattern indicated by channels (contours) blocked in with printed numbers; this pressure pattern is then outlined in heavier black lines for additional clarity and photographed before being distributed to the sponsoring agencies (see sample in figure 1).

Dr. Fred Schumann, left, and Mr. O. Fuller at the controls of the IBM 701. IBM photo.

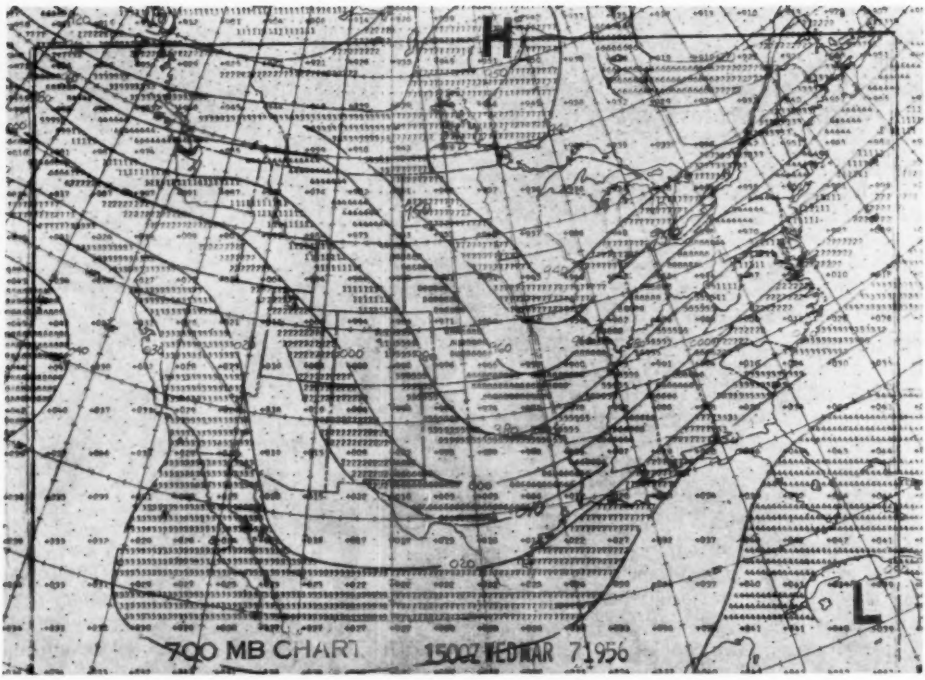


FIG. 1. Machine analysis at the 700 mb level for 1500 GCT, 7 March 1956, showing the contour shading as printed out by the computer.

The Analysis Section, being closest to the operational user, conducts a daily discussion of the numerical forecasts and compares them with actual observations as well as with forecasts using standard techniques. These discussions aid the Development Section in following trends and weaknesses of the numerical product thereby suggesting methods for improvement. Any adopted changes are then passed to the Computation Section for incorporation into the machine code. Each section is thus a vital part of a tightly integrated unit even though internally they perform widely diversified jobs.

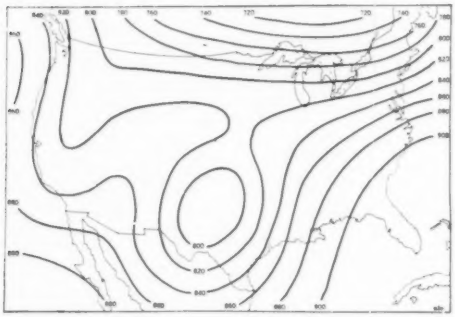


FIG. 2. Machine analysis at 500 mb for 1500 GCT, 5 February 1956. Solid lines are height contours at intervals of 200 feet.

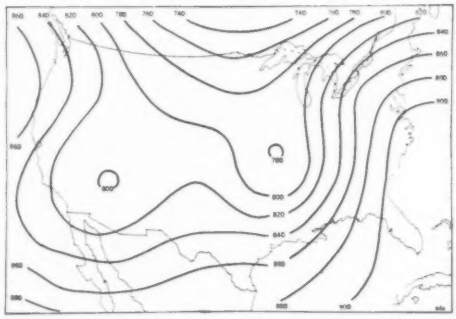


FIG. 3. Twenty four-hour machine forecast at 500 made from initial chart in figure 1 and verifying at 1500 GCT, 6 February 1956.

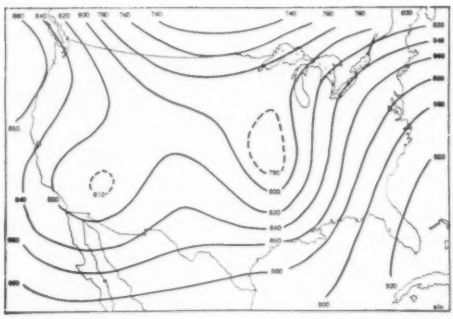


FIG. 4. Observed 500 mb pattern at 1500 GCT, 6 February 1956.

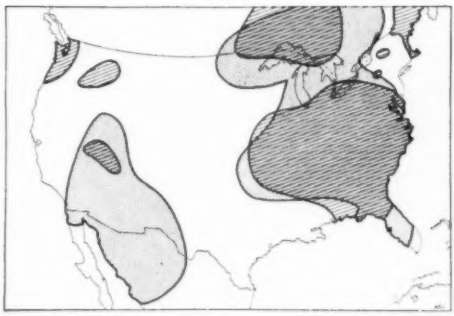


FIG. 5. Vertical motion and precipitation chart covering 24-hour period from 1500 GCT, 5 February to 1500 GCT, 6 February 1956. Dotted areas indicate regions where mean ascending motion between the surface and 10,000 feet was forecast to exceed 5 mm/sec. Diagonal hatching indicates areas where measurable precipitation fell during the period.

A Numerical Forecast Example

Experience has shown that in spite of the many simplifying assumptions in the models now being used, they are frequently good representations of actual conditions in the atmosphere. When this is the case, numerical forecasts using present techniques are also good; in fact they are often better than those obtained using standard forecast methods. At other times, however, it must be admitted that the present models do not closely represent atmospheric conditions, and the assumptions made in the forecast equations are far too restrictive.

The example which has been selected for presentation here is one in which the model was representative and a good forecast was obtained. The three-level model mentioned earlier was used in this particular case. The initial analysis made by the machine for the top of the three levels (500 mb) at 1500 GCT, 5 February 1956, is shown in figure 2. A low-pressure center was located over Texas, and a trough was approaching the Rocky Mountains from the northwest. Figures 3 and 4 show the forecast and observed flow patterns 24 hours later at the same level. It is obvious that the results here were excellent; the trough was forecast to deepen and become a closed low center over Arizona, and the Texas low to move northeastward across the Mississippi Valley. Both changes occurred as forecast.

The three-level model also yields a forecast of the large-scale vertical motion in the atmosphere. Air particles which ascend or move to a higher level are normally cooled and therefore cannot hold as much water vapor. If enough moisture is present initially and if ascending motion continues long enough, condensation will occur (clouds will form) and rain or snow may fall. These forecast vertical motions are therefore very useful to the meteorologist since they indicate areas where cloudiness and precipitation are most likely to occur.

The dotted portions of figure 5 show the areas which were forecast to have a mean ascending motion between the surface and 10,000 feet greater than 5 millimeters per second sometime during the 24-hour period covered by figures 1 and 2. They indicate where one is most apt to observe cloudiness and precipitation providing enough moisture is present in the air. The areas where measureable precipitation, either as rain or snow, was observed during this period are shown by diagonal hatching. The overall correspondence is again good. It seems likely that the air over the southwestern United States was too dry for precipitation to take place, while the observed rainfall over the Pacific Northwest was due to air being forced up over the mountains.

Future Developments

The initial approach to the problem of issuing daily numerical forecasts was purposely made as simple as possible. The capabilities and short-comings of the simplest

(*Continued on page 106*)

The damaged runway at Craig Field after tornado passage. Deane Studios photo.

Jacksonville Tornado

ROBERT G. BEEBE, *Severe Local Storm Warning Center, U. S. Weather Bureau, Kansas City, Missouri*

ON 13 December 1954, a small tornado struck Craig Airport, Jacksonville, Florida, at 1824 EST. This particular Sunday in Jacksonville was characterized by low cloudiness and fog with intermittent light rain throughout most of the day. At the Municipal Airport, the temperature stayed around 70° F., except for a short time during the afternoon when a maximum of 76° was recorded, and the dew point remained near 69° throughout the day. A thunderstorm, which began at 1805 EST and ended at 1908 EST, was associated with heavy showers for a few minutes. The surface wind was from a southwesterly direction from 10–15 mph during the afternoon and evening, and with no gustiness even at the time of the thunderstorm. The Craig Airport where the tornado occurred at 1824 EST is located about 9½ miles southeast of the Municipal Airport.

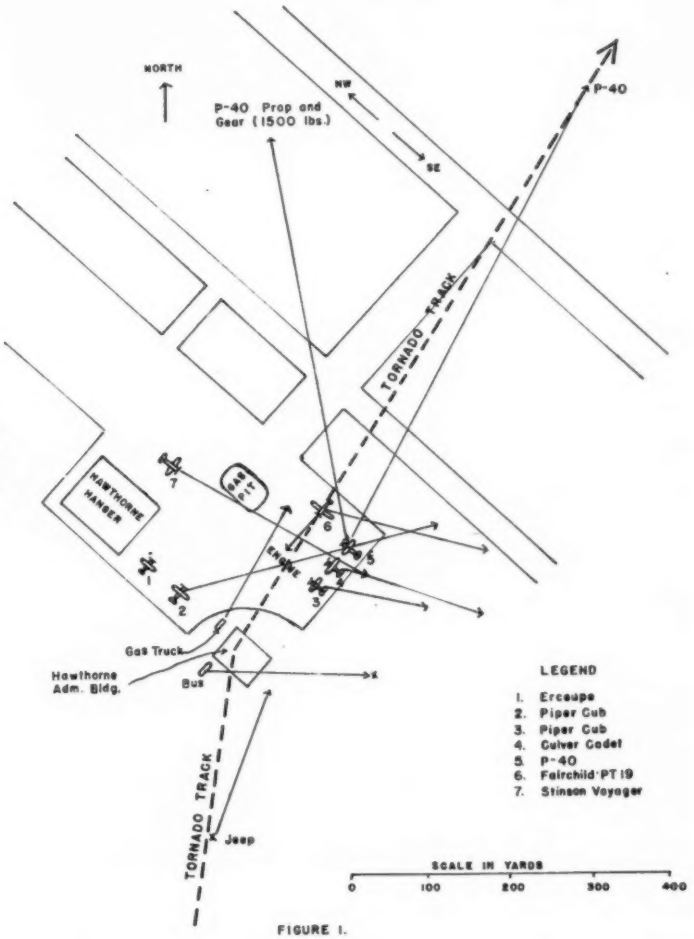
The tornado roar was heard by several persons at a small store about 1.5 miles south of Craig Airport, but there was no damage along the path until it reached Craig Airport. There it passed near one hangar and turned over some light planes that were tied down outside. As the tornado roared northward, it evidently dipped to the ground and picked up a jeep which it carried some 200 yards, completely demolishing it. The Hawthorne Flying Service Administration Building, directly in the path of this tornado, was completely demolished. Here the tornado took a northeasterly course for about 300 yards. Beyond

this point, both over the airport and woods beyond, there was evidence of only slight damage (some trees were twisted a little).

Figure 1 is a sketch of the section of Craig Airport that was struck by the tornado. The arrows show the estimated path taken by the seven airplanes, jeep, gas truck, and bus as the tornado struck. The itinerant airplane tied down at point 1 was not damaged at all and was flown away the next morning. The P-40, the largest plane of seven, was thrown into the woods about one-half mile away. The propeller and gear section from this plane, weighing 1500 pounds, was thrown about 500 yards from where the plane was tied down.

The demolished jeep may be noted in the upper right, while the wind T, upper left, located about 500 yards from the Administration Building was only slightly damaged. The gasoline truck was moved only a few feet and was not damaged even though it was originally parked near the center of the tornado track.

The photographs shown in figures 2 and 3 were taken looking to the northeast. In figure 2, note the undamaged gasoline truck standing in an area where the 5″ asphalt taxiway was completely destroyed. Also, note the scattering of the broken chunks of asphalt to the right of the tornado track while the area to



Craig Field at Jacksonville, Florida. The dashed arrow represents the path of the tornado funnel and the solid arrows show the movement of the jeep, bus, and airplanes.

FIGURE 1.

the left of the track is almost completely clear of asphalt chunks. The 3″ lime rock layer which was the base for the 5″ asphalt was not damaged.

If a cyclonic rotation around the tornado vortex is assumed, it appears from these last two photographs that the major damage to the asphalt ramp and taxiway resulted from the explosive action of the low pressure in the tornado vortex. The winds on the trailing edge of the tornado vortex then threw the loose chunks of asphalt to the right of the track. At the same time the wind on the leading edge of the vortex evidently did no damage to the asphalt.

At the time of this tornado, Jacksonville was within a general rain area. The radar in the Jacksonville Control Tower, as should be expected, showed this rain as rather general solid echoes over all the scope which was on a 20-mile range. However, Mr. C. W. Mason, one of the tower operators, noted an unusual "hole" or dark area on the scope around 1830 EST which lasted only a few minutes. This "hole" was circular, estimated to be from ¼ to ½ mile in diameter, and was moving approximately from the southwest to the northeast. As it developed later, this "hole" was noted at about the time and site of the tornado which struck Craig Airport.

The author gratefully acknowledges the help of Mr. Roger G. Plaster in securing data; to Deane's Studios, Jacksonville Beach, Florida, in making these tornado damage photographs available for study and reproduction; and to Mr. Beverly Howard and Mr. W. F. Wilkinson of the Hawthorne Flying Service, Moultrie, Georgia, for their help in providing information used here.

A close view of the runway damage showing the explosive effect of the tornado passage. Deane Studios photo.

This is the first of a series of six articles which will appear in forthcoming issues of *Weatherwise*. Each article will discuss the prevailing tracks of highs and lows for the two months following the publication month.

Prevailing Tracks of Lows and Highs

WILLIAM H. KLEIN,
Extended Forecast Section,
U. S. Weather Bureau,
Washington, D. C.

INTRODUCTION

THE purpose of this series of articles is to discuss briefly the outstanding climatological features and month-to-month evolution of the prevailing tracks of cyclones and anticyclones at sea level in most of the Northern Hemisphere. These tracks were recently prepared by the author by combining relevant material from many previous studies with new data from the *Historical Map Series*, the *Monthly Weather Review*, and the *Normal Weather Charts*. The tracks for the entire hemisphere and the complex procedure by which they were derived are presented in detail in a forthcoming publication,* which also describes the history of the subject, the mean meridional distribution of pressure centers, and application of the tracks. This publication contains charts showing the geographical frequency of lows, highs, cyclogenesis, and anticyclogenesis in the Northern Hemisphere during each month of the year. Although these charts will not be reproduced in *Weatherwise*, some of their principal regional characteristics will be included in the following discussion.

The cyclone and anticyclone tracks to be presented here will supplement the Weather Bureau's normal maps of sea level and upper-level circulation. However, derivation of the tracks was independent, for the most part, of the intensity of systems or the location of semi-permanent centers of low or high pressure. In all cases the primary consideration was the frequency of migratory cyclones and anticyclones. Hence, the final tracks depict not only the most frequent or primary tracks, but also preferred secondary tracks which may predominate in special, yet frequent, synoptic situations.

Many of the features to be pointed out in the ensuing discussion have long been known to climatologists and synoptic meteorologists and have been noted in previous publications. Nevertheless, it is believed that a comprehensive review based upon the best data currently available will be of considerable interest and value. It should be borne in mind that only the customary behavior of systems is being discussed; individual days, months, years, or even decades may exhibit large deviations from the normal pattern.

JULY—CYCLONES

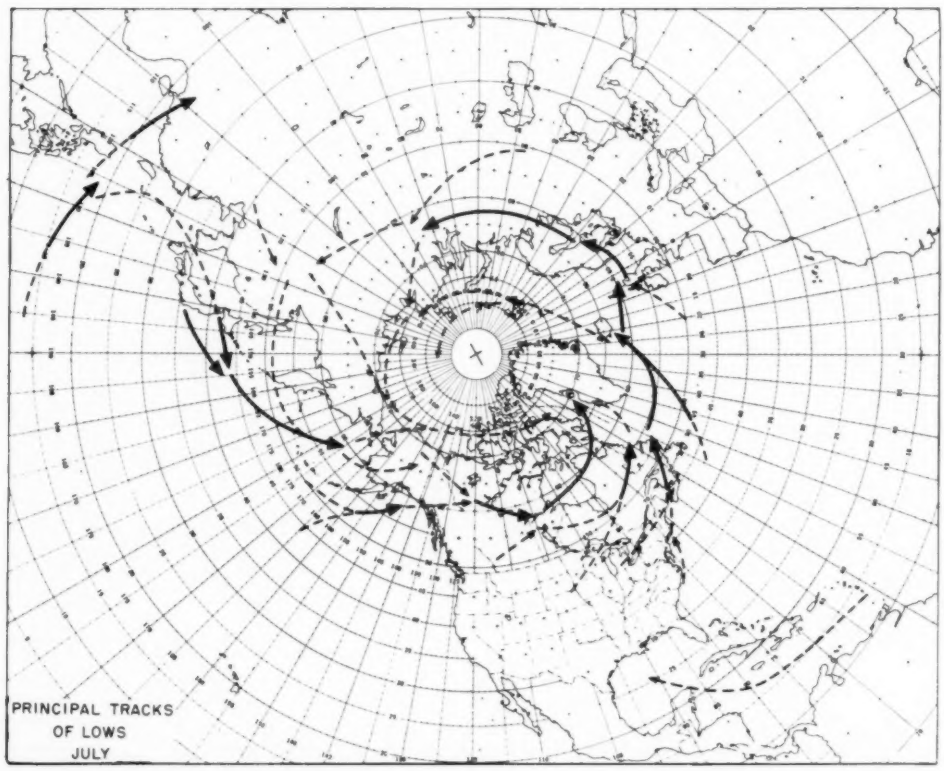
During July cyclones are relatively infrequent in the United States, and no primary storm tracks are located anywhere in the country. On the other hand, cyclones are abundant in Canada, where fronts and troughs from the Pacific frequently produce closed sea level lows on the lee (eastern) slopes of the Rocky Mountains. Most of these storms follow a well defined primary track across central Canada and Hudson Bay into Davis Strait. However, some cross southern Canada before entering a pronounced center of maximum cyclone frequency in Labrador. Many of the lows contributing to this center form as secondaries in the United States; either

* "Principal Tracks of Cyclones and Anticyclones in the Northern Hemisphere," *U. S. Weather Bureau Research Paper No. 40*, 1956.

along the East Coast, near the Great Lakes, or in the northern Plains. From Labrador most of the cyclones travel northeastward across the Atlantic to Iceland, where they are joined by storms which develop south or east of Newfoundland. Some of the Icelandic lows continue northeastward into the Arctic Ocean, but the majority follow a zonal trajectory along a well defined primary track which extends from the eastern Atlantic into western Siberia. Few of these cyclones are able to traverse eastern Siberia, where several secondary tracks are indicated, because of the great strength of the semi-permanent monsoon circulation.

Although a few tropical hurricanes may appear in the Caribbean Sea or Gulf of Mexico during July, they are comparatively rare. Typhoons of the western Pacific, by contrast, are very frequent, with one group passing just north of the Philippines and another just west of Japan. Frequent cyclogenesis around northern Japan converts the secondary typhoon track into a primary track of both tropical and extratropical lows. This track extends northeastward across the Pacific into a marked center of maximum cyclone frequency in the Bering Sea. From here the cyclones continue northeastward, either into a center of maximum frequency in northern

Principal tracks of cyclones and anticyclones at sea level. The prevailing direction of motion of systems is indicated by the arrows. Heavy solid lines denote primary tracks—those which are most frequent and generally indicated by various data sources; thin dashed lines denote secondary, less frequent, and less well defined tracks. All arrow heads end in areas where cyclone frequency is a local maximum. Here the tracks may cross, branch, and merge, although not specifically so drawn. Locally preferred regions of genesis are indicated where secondary or primary tracks begin, whether in centers of maximum cyclone frequency or elsewhere. An area of frequent genesis is also indicated when a single secondary track changes to a single primary track or when two secondary tracks merge to form a primary track, with a break between dashed and solid lines.

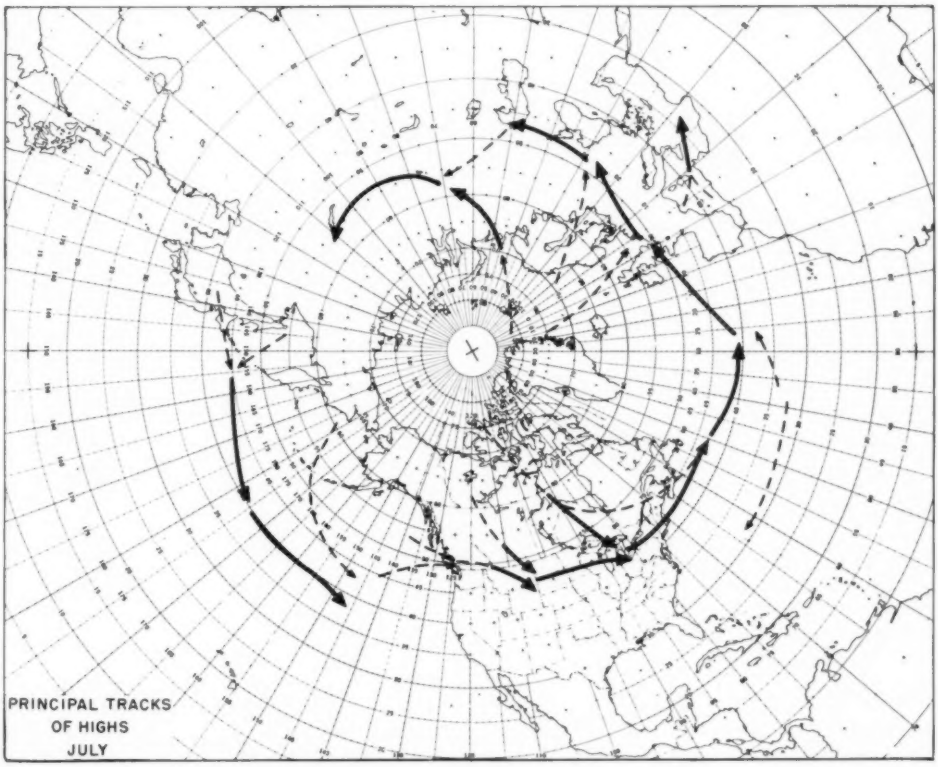


Alaska, or into the Arctic Ocean to join the polar track along the northern coasts of Asia and North America. Some secondaries develop south of the main centers and proceed into the Gulf of Alaska, where cyclonic activity is frequent all year long.

July—Anticyclones

During July the primary anticyclone tracks have a fairly simple appearance. They extend for the most part in a zonal fashion, across the Pacific between 40° and 45° N., across North America and the Atlantic between 40° and 50° N., and across Europe and Asia between 45° and 55° N. The primary track across the northern tier of states in the United States is particularly significant because it exists virtually unchanged during the four summer months, June through September. It passes directly across the Great Lakes, where an area of maximum anticyclone frequency is centered and where it is joined by a primary track of polar highs from central Canada. Polar highs emanating from western Canada usually enter the United States in the northern Plains. Here anticyclone frequency is greater during July than any other month of the year, and a separate center of high pressure appears over Wyoming on the normal sea level chart. Many American highs are formed in this area, which leads the Northern Hemisphere in anticyclogenesis during July.

In spring and summer the effect of locally cold bodies of water as sources of anticyclonic vorticity is marked. As a result, primary anticyclone tracks originate during July over the Mediterranean, Barents Sea, and Hudson Bay. Moreover, secondary tracks are found over the cold waters of the Greenland Sea, Norwegian Sea, Sea of Okhotsk, and Bering Sea. An interesting feature of the July anticyclone chart is the fact that the secondary track in the Atlantic between 30° and 35° N. is directed westward (instead of eastward as in earlier months), towards a center of maxi-

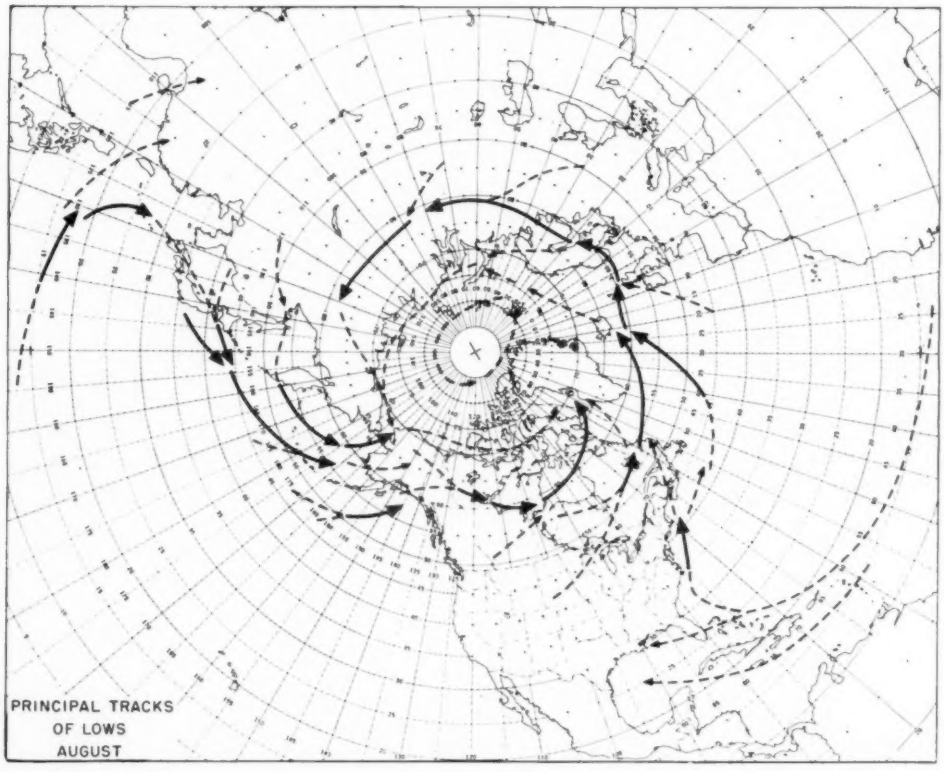


mum frequency near Bermuda. This reflects the fact that the subtropical easterlies normally extend as far north as 30° N. during mid-summer.

August—Cyclones

In August the axis of the hemispheric west wind belt is normally farther north than in any other month. The principal storm tracks are, likewise, farthest north, with the primary track around 60° N. across North America, the Atlantic, and Eurasia. Secondary tracks are found even farther north, at both 70° and 80° N. The main Pacific track is well north of the Aleutians. As a result, storminess reaches its annual maximum in the Bering Sea, and another center of maximum cyclone frequency appears in the Bering Strait. At the same time cyclone frequency in the Gulf of Alaska is less than in any other month, although a local maximum is still present. Storms are also infrequent in the United States but very common in central Canada. In fact the number of different lows per 5° box in the Canadian prairie provinces is equaled only by that in the Icelandic area.

Not only the zonal westerlies, but also the subtropical easterlies are normally farthest north in August. Typhoons are now displaced so far north that they usually miss the Philippines entirely, and some pass directly across western Japan. Increased frequency of typhoons in August results in the appearance of two additional centers of maximum cyclone frequency, one over the Ryukyu Islands and one on the China coast. In the Western Hemisphere the frequency of tropical storms increases greatly. Some disturbances originate in the vicinity of the Cape Verde Islands, develop as they are carried across the southern Atlantic by the prevailing easterlies, and then enter the Caribbean, Gulf of Mexico, United States, or western Atlantic as full-fledged hurricanes. Characteristic of this activity is the split track around the West

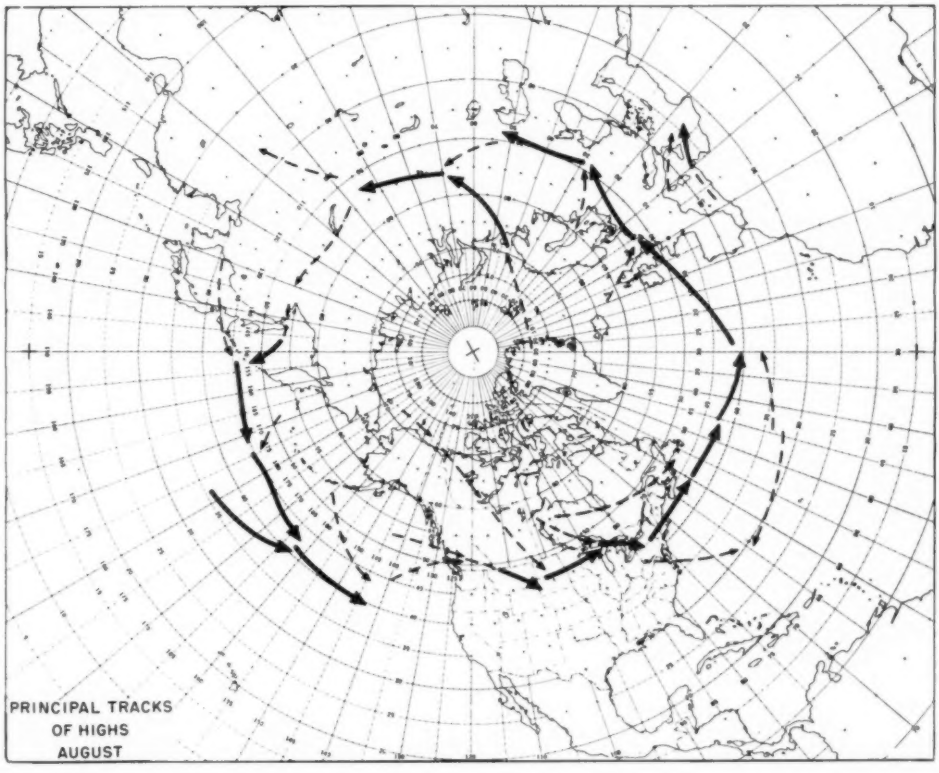


Indies, with one branch passing to the north and one to the south of the islands.

August—Anticyclones

On an overall basis the principal anticyclone tracks, like the principal cyclone tracks, are farthest north during August. However, the northward displacement from July is slight, being perceptible only in Europe, the western Pacific, and the Great Lakes region. In the United States, the primary track across the northern border states is very well defined, as anticyclone frequency increases throughout the northern part of the country, especially in New York and Pennsylvania. Along the border between these two States the number of different highs per 5° box is one of the largest of any month in the entire hemisphere. Since most of these highs move eastward across the Atlantic, anticyclone frequency also reaches its high point of the year in this sector. Likewise, the incidence of anticyclones increases in the Middle Atlantic States, as some of the highs from the Pennsylvania area move southeastward toward Bermuda.

The track of polar highs in North America undergoes a westward shift from July to August. Instead of passing through the Canadian archipelago and western Hudson Bay regions, as in the four months from April to July, it now crosses the Beaufort Sea, Mackenzie Valley, and Canadian prairie provinces in a fashion similar to winter. However, the frequency of these polar outbreaks is quite low. Warming of Hudson Bay puts an end to appreciable anticyclogenesis in this region, although some polar highs still form in nearby Manitoba. In the Soviet Union the primary track of polar highs is well marked, and anticyclone frequency in the Barents Sea reaches its high point of the year. Anticyclone incidence also increases in east Asia, where two secondary tracks appear, and in the eastern Pacific High cell, where it reaches its annual maximum.



A Climatological Bench-Mark Network

STATIONS SELECTED FOR CLIMATOLOGICAL BENCH-MARK NETWORK
(ABOUT 20 MORE TO BE SELECTED LATER)
TATOOSH ISLAND
BLAKE RANCHES
BOZEMAN AGRIC COLLEGE
DICKINSON EXP STA
ITASCA STATE PARK
CHATHAM MICH ST EXP FARM
GENEVA EXP STA
STEPHENTOWN
MT. WILSON
LOGAN STATE AGRIC COLLEGE
RENO AGRIC COLLEGE
CRETE (DANE COLLEGE)
URBANA (UNIV OF ILLINOIS)
WOOSTER EXP STA
WOODSTOCK COLLEGE
MONTROSE NO. 2
ROCKY FORD
GRAND CANYON NAT'L PARK HOSPITAL
STILLWATER (OKLA A. AND M. COLLEGE)
LEWISBURG EX. STA
WINTHROP COLLEGE
STATE COLLEGE MISS AGRIC EXP STA
N. M. STATE AGRIC COLLEGE
EXTRA-CONTINENTAL STATION
U. S. MAGNETIC OBSERVATORY, HONOLULU, T. H.
COLLEGE STATION (TEXAS A. AND M. EXP STA.)
ST. LEO ABBEY
NOTE ALSO: THE ABOVE SELECTIONS ARE SUBJECT TO COMPLETE STATISTICAL ANALYSIS OF PRIOR RECORDS
SUPPLEMENTARY STATIONS (TEMPERATURE-PRECIPITATION ONLY)
PRELIMINARY SELECTIONS
EXTRA-CONTINENTAL STATION
SAN JUAN, P. R. (W. B. O.)

JOHN R. SWARTZ, *U. S. Weather Bureau, Washington*

As climatological records lengthen, the need increases for a permanent reference base —an analogue to a datum level used for elevation measurements and records—by which to detect and evaluate climatic trends. This is not a new thought—Heinrich Dove in 1845 already had referred to standard stations. To meet this need, the Weather Bureau plans to designate certain climatological stations, as "Climatological Bench-Marks." A primary requirement for such stations, next to high quality of records, is permanence. Stations for the bench-mark network will be those where location, elevation, and exposure of instruments have not been, and are not likely to be, changed.

The purpose of these stations is to measure the nature and magnitudes of slow, secular changes in climatic conditions, and to aid in seeking their causes. Such changes could have a major impact on commerce and agriculture. The selection of bench-mark stations from the existing stations at places where no major changes in immediate surroundings have occurred or are anticipated is now under way. Stations maintained cooperatively with other federal and state agencies, universities, farm experimental stations, and the like offer the best prospect.

High-quality weather observations are being taken in the United States at over three hundred stations manned by full-time Weather Bureau employees. At these so-called first-order stations, however, the readings are taken primarily to serve the needs of the weather forecaster and climatological information is strictly a by-product. Therefore, both the location of the stations and methods of observation frequently change with the requirements of the forecast system. In the cooperative station network, also, locations are subject to change. Observers retire or change, exposures change, town influences change. Thus, in the first-order, and the cooperative networks as well, about half the stations undergo a change in less than a decade. For many practical applications of climatology these changes of site are not necessarily important, because statistical adjustments can be made to bridge them for general comparisons. However, the issues related to climatic change become beclouded from records broken and altered by such changes.

Evidence has accumulated in recent decades that rather large-scale climatic changes have taken place over the Northern Hemisphere. Much has already been written about the economic importance of such changes. They affect all major sectors of the agricultural and business world as well as every individual. Changes in the frequency of rainfall and drought and the degrees of heat and cold exert a profound influence on farm prosperity, the fuel industry, building and construction activities, the insurance business, clothing manufacture, and the production of heating and cooling equipment. They are reflected in our daily lives in such things as the size of fuel bills or adequacy of water supplies.

It is, therefore, essential to determine the magnitude of these changes accurately and to study their trends. They take place very gradually, and many years of observations are needed to establish them. The observations for this purpose should be taken in an undisturbed environment. When our predecessors started meteorological observations, it was natural that data were first collected for the centers of population. This is still important for many purposes. But meteorological stations in growing cities are profoundly influenced by the changing environment. Domestic and industrial heating, air pollution, changes of the natural soil and vegetation affect the temperature, moisture, and winds of the vicinity. These man-made changes may be as great locally as the slow, natural variations of climatic conditions. Moreover, it has frequently been impossible to keep urban Weather Bureau stations in the same spot.

From the foregoing the importance of maintaining some meteorological stations for the specific study of long-term climatic trends becomes apparent. Observations of this type may also shed some light on the climatic fluctuations which may influence hurricane tracks and tornado frequencies. The data collected at such stations may provide evidence for better assessment of the effects of

(*Continued on page 106*)

Weather and the San Fran

PHILIP WILLIAMS, JR., *U. S.*
Salt Lake City,

IT is fifty years since the great earthquake and fire of April 1906 devastated a large portion of San Francisco. In the words of A. G. McAdie, California section director of the local Weather Bureau, "The morning of April 18, 1906 was clear and pleasant over the greater portion of the Pacific Coast. An area of high pressure was moving steadily and somewhat slowly eastward over Idaho. The weather map (at 0500 PST shown in figure 1) gives the conditions existing a few minutes previous to the earthquake. . . ."

The plateau high mentioned by Prof. McAdie brought warm, dry northeasterly winds to the central California coast. As a result, old-time residents of the Bay region, recalling the weather at the time of the 1906 disaster, still mention the possibility of earthquakes whenever unseasonably warm, dry weather prevails. While the weather most likely had nothing to do with the occurrence of the great earthquake, it did have much to do with the spread of the devastating fire which followed the temblor and burned for three days.

The weather map for 0500 PST on 18 April 1906 is taken from the published *Historical Weather Map* series. A large high is centered over northern Idaho and eastern Washington, with low pressure over Arizona.

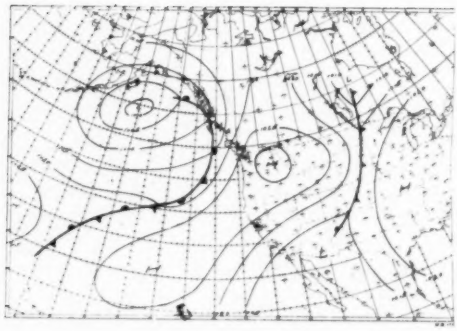
n Francisco Fire of 1906

R., *U. S. Weather Bureau,*
ke City, Utah

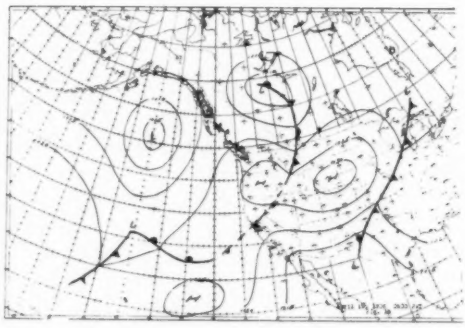
The isobars along the central California coast indicate a northeasterly flow of air from the Plateau. Under these conditions, the air usually becomes very warm and dry as it reaches the coastal lowlands. An occlusion is approaching the British Columbia and Washington coasts, with indications of a wave forming on the southwest portion of the front.

The main shock of the earthquake occurred at 0515 PST and lasted about 40 seconds. Fire broke out shortly thereafter in the business district in the eastern portion of the city, and firemen were unable to control the spreading flames for lack of water, the mains having been broken by the earthquake. Aided and abetted by the warm, dry weather (no measurable rain had fallen in San Francisco since 1 April) and general easterly flow, the fire spread rapidly westward through the business district into the residential areas.

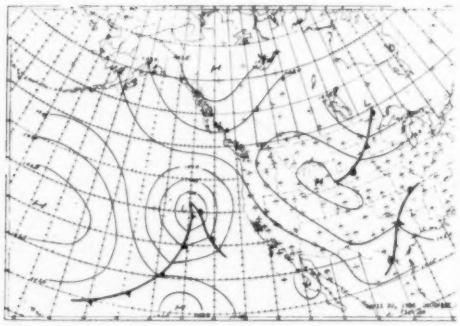
By the weather map time of 0500 PST on the 19th, the occluded front shown off the coast on the 18th had dissipated in northern California and pressure remained high over the Plateau. A pronounced wave took form about 500 miles west of the California coast. The day was warm and dry in the Bay region, with the temperature reaching 81° F.



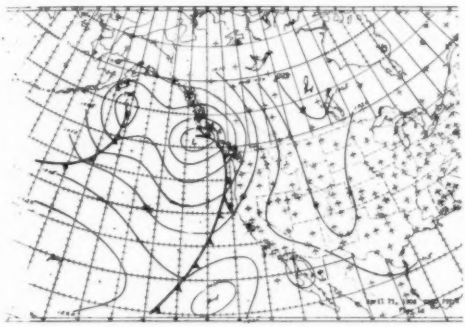
Surface map, 0500 PST, 18 April 1906.



Surface map, 0500 PST, 19 April 1906.



Surface map, 0500 PST, 20 April 1906.



Surface map, 0500 PST, 21 April 1906.

at Oakland compared to a normal maximum of 63° F. for that day. The table below shows the maximum temperatures at Oakland and Berkeley, both eastward across the Bay from San Francisco, during the period 17–22 April. The instruments at the San Francisco Weather Bureau were destroyed by the fire, and temperatures in that city would undoubtedly have been influenced considerably by the fire.

TABLE I

MAXIMUM TEMPERATURES, APRIL 1906

Date	17	18	19	20	21	22
Oakland	67	70	81	80	64	64
Berkeley	65	68	81	79	64	60

On the afternoon of Thursday the 19th, city officials decided to attempt to check the westward spread of the flames by dynamiting a block-deep row of houses along Van Ness Avenue, a broad north-south street through the then fashionable residential district. The dynamiting continued throughout Thursday night and Friday, 19–20 April.

Friday morning's weather map showed pressure still high over the Plateau with a weak gradient along the California coast. The Pacific wave, however, deepened into a vigorous low about 400 miles off the northern California coast. This was the last warm, dry day. By late Friday, according to contemporary reports, a strong westerly wind began blowing, aiding fire fighters to maintain their Van Ness Avenue fire line. The

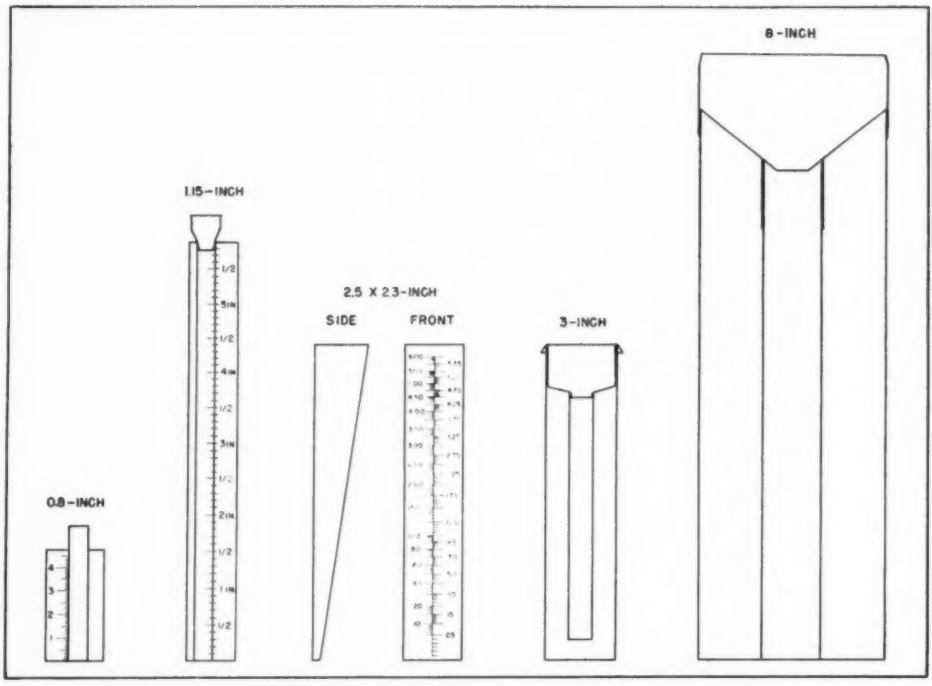
strong west wind blew the flames back over the burned area, so that it was possible for the main conflagration to be extinguished Friday night, although some new areas continued to burn in the northeast portion of the city.

The synoptic situation at 0500 PST, Saturday, 21 April, reveals a deepening wave, which was off the California coast on the previous day, as having occluded and moved northeastward to Vancouver Island with the occlusion line extending southward along the Pacific Coast. San Francisco reported a west wind of Beaufort force three at map time; observations had apparently been resumed. The hot spell was broken on the 21st when a maximum of only 64° F. was recorded at Oakland. The occlusion passed San Francisco late Saturday night accompanied by half-an-inch of rain, causing considerable discomfort to the thousands of refugees camped out in Golden Gate Park, the Presidio, and other open areas.

Approximately 435 people were killed and 3,500 seriously injured in the earthquake and ensuing fire. Total damage was estimated at $250 million, a sum that would be near a billion present-day dollars, making it one of the most costly natural disasters in the history of our country. Nearly one-half of the city of 400,000 inhabitants was destroyed, including practically the entire business and financial section.

Had the normal cool, damp, fog-laden, prevailing westerlies been blowing across San Francisco when the fire broke out, it is quite possible that the fire would have been confined to the lower business areas and rapidly burned itself out along the bayshore waterfront.

Street scene—San Francisco 1906. Bettmann Archive photo.



Outline of gages employed in comparative study.

Comparison Between Standard and Small-Orifice Raingages

F. A. HUFF, *Illinois State Water Survey, Urbana, Illinois*

DURING 1953–54 an observational program was carried out in central Illinois to compare the rainfall catch obtained from four types of small-orifice gages with that from the U. S. Weather Bureau standard 8-inch stick gage. The small-orifice gages, which are drawn to scale in figure 1, consisted of three cylindrical gages having catch diameters of 3 inches, 1.15 inches, and 0.8 inch, and a wedge-shaped gage having a rectangular catch area of 2.5 inches by 2.3 inches.

Two sets of the small-orifice gages were operated in conjunction with two standard 8-inch gages from March to November 1953–54. The small gages in each set were installed at distances of 6 feet from the 8-inch gage to form a circular pattern on level meadow land (figure 2). Observations were made at the conclusion of each storm.

Scatter diagrams comparing the various small gages and the standard 8-inch gages are shown in figures 3–7. Examination of these graphs indicates that the wedge-shaped and 3-inch gages compared best with the standard 8-inch gage.

Results of the data analysis, in which storm size and wind speed were taken into

consideration, indicate that the small-orifice gages are satisfactory for use in place of the standard 8-inch gage for measuring rainfall under most circumstances. No tests of the gages were made during snowfall. The 1.15-inch and wedge-shaped gages are constructed of plastic while the 0.8-inch gage is made of glass, so their use is not recommended during freezing weather. The analytical results are summarized in table I, where median ratios of each test gage to standard gage have been grouped according to wind speed and to total rainfall (storm size) at the standard 8-inch gage.

No opinion is offered regarding the absolute catch efficiency of the various gages. Comparisons were based entirely upon compatability with the 8-inch gage, which is the generally accepted standard for rainfall measurements in the United States. Of the particular gages tested, the wedge-shaped and 3-inch gages gave the best comparison with the 8-inch gage.

Comparison with results of a rainfall gradient study indicated that the average rainfall variability in shower-type rainfall within a distance of one mile is generally greater than that observed between any of the small gages and the standard gage at a given site.[1]

[1] Huff, F. A. and Neill, J. C., "Variation of Point Rainfall with Distance," Illinois State Water Survey, 1955 (to be published).

TABLE I

EFFECT OF WIND SPEED AND STORM SIZE ON CATCH OF VARIOUS GAGES

Median Ratio for Given Storm Sizes
2.5-in. × 2.3-in./8-in.

Wind speed (mph)	.01"–.19"	.20"–.49"	.50"–.99"	1.00"–2.00"	All storms
0–10	1.00	0.98	0.99	1.02	1.00
11–20	1.00	0.99	0.98	0.99	0.99
3-in./8-in.					
0–10	1.00	1.00	1.00	1.00	1.00
11–20	1.09	1.03	1.00	0.97	1.01
1.15-in./8-in.					
0–10	1.15	1.03	1.00	1.00	1.04
11–20	1.25	1.02	0.96	0.97	1.02
0.8-in./8-in.					
0–10	1.30	1.09	1.05	1.08	1.13
11–20	1.25	1.11	1.05	1.05	1.10

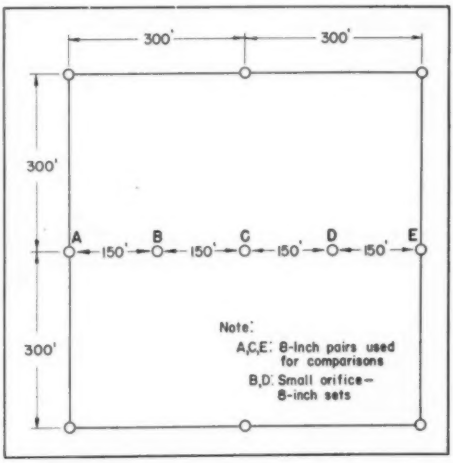


FIG. 2 LOCATION OF COMPARISON GAGE SETS WITHIN MICRO-NETWORK

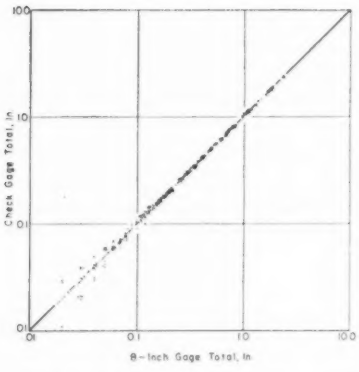


FIG.3 COMPARISON BETWEEN 8-INCH GAGES, 6 FEET APART

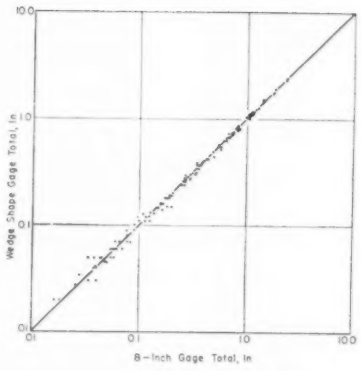


FIG.4 COMPARISON BETWEEN 8-INCH AND WEDGE SHAPE GAGES

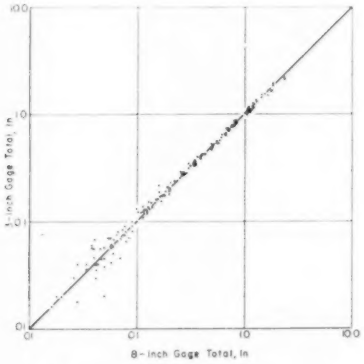


FIG.5 COMPARISON BETWEEN 8-INCH AND 3-INCH GAGES

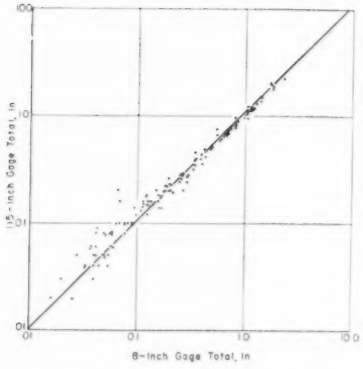


FIG.6 COMPARISON BETWEEN 8-INCH AND 1.15 INCH GAGES

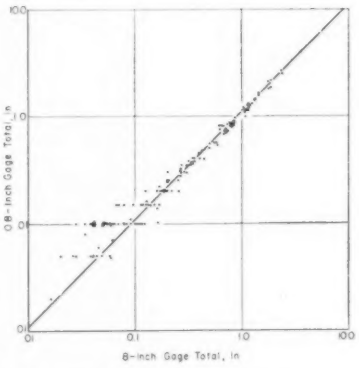


FIG.7 COMPARISON BETWEEN 8-INCH AND 0.8-INCH GAGES

Some Observations on the Tornado at Blackwell, Oklahoma 25 May 1955

Reported by FLOYD C. MONTGOMERY,
a weather observer in Blackwell, Oklahoma

ON May 25, 1955 at 8:30 P.M. a line of thunderstorms moved on this city with light hail and a hard west wind. The life of the storms was short and they were soon over. Things seemed to fair up and people went home from our cave. Then a violent thunderstorm broke out. There was no rain but much lightning. The strokes were 1, 2 or 3 seconds apart and you could feel the earth shake when they hit. The cloud seemed to come back from the east-south-east, and very large hail stones fell. Some were measured having a diameter of 2½ inches. Some of the big ones buried themselves in my lawn. Soon after the tornado moved in from the south, I stood in the door of my storm cellar and watched the storm go through town. The tornado hit town at 9:27 P.M. The wind at my place, nine blocks west of the main path, was a dead calm. The storm sounded like a roaring freight train going through open country—only louder. As the storm was directly east of me, the fire up near the top of the funnel looked like a child's Fourth of July pin wheel. The light was so intense I had to look away. A sketch of what I saw is enclosed.

As near as I can explain, I would say it was the same color as an electric arc welder but much brighter, and it seemed to be turning to the right like a beacon lamp on a lighthouse.

A few minutes after the storm passed, there was a taste and smell in the air like that of burnt sulfur. The air was clammy, and it was hard to breathe. It was like being smothered.

One lady who saw the storm tells me that before it hit, she turned on her television set but could only get a loud hum and a blank screen as though a power tube had burned out. She turned on her radio and it too gave just a hum. She then walked to the front door and looked out and saw "lightning" coming up from the ground, two or three feet high and about half as wide as adding machine tape. It was a deep blue and was forked on the end like a "Y" or like a snake's tongue. She saw the tornado as a black wall, so she ran to the staircase and took cover under it. The tornado destroyed her two story house and carried her one-half block away still under the staircase.

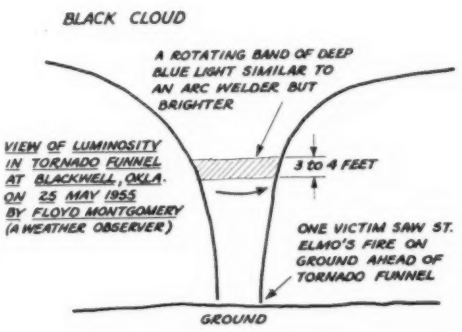
In answer to a question about noises of electrical discharges, the editor of the newspaper here said he heard hissing sounds before the tornado blew the roof of his house away, but he had thought it was due to changes in air pressure.

Many people heard the buzzing radio static. It had a constant crackle and made it impossible to get any TV or radio station.

The tornado caused a lot of odd things. Among them are the following:

The air near the funnel felt hot. At my instrument shelter, the temperature on my maximum thermometer rose from 74° F (where it had been since 7 P.M.) to 80° F when the storm struck. I noted that recording thermometers at the Journal and the Consolidated Gas office both showed a sharp rise to 80° at the time of the storm, 9:27 P.M. (There was no humidity data taken.)

(Continued on page 101)


BLACK CLOUD
A ROTATING BAND OF DEEP BLUE LIGHT SIMILAR TO AN ARC WELDER BUT BRIGHTER
VIEW OF LUMINOSITY IN TORNADO FUNNEL AT BLACKWELL, OKLA. ON 25 MAY 1955 BY FLOYD MONTGOMERY (A WEATHER OBSERVER)
3 to 4 FEET
ONE VICTIM SAW ST. ELMO'S FIRE ON GROUND AHEAD OF TORNADO FUNNEL
GROUND

More About Meteorological Books—1954-56

MALCOLM RIGBY, *Editor, Meteorological Abstracts and Bibliography*

THIRTY-five textbooks, popular science books, and specialized works on various aspects of meterology published in 1953 and 1954 were discussed informally in two articles appearing in the April and June 1955 issues of *Weatherwise*. The last year has provided a wealth of new books of every kind, to whet the appetite and drain the pocketbook of each and every lover of books or student of meteorology who wants to maintain a library along the lines of his interests.

It is not possible for one reviewer to do justice to all of these fine publications; all he can hope to do is to convey to the reader some of his interest in, or enthusiasm for, a book or a subject. *Unfortunately*, not everyone has the same interests. *Fortunately*, interest and enthusiasm are contagious—unfortunately often to the point of arousing the enthusiasts to deadly competition. A reviewer would, indeed, feel flattered, in a macabre way, if his reviews would lead to such a rush for copies of the books reviewed that people would be trampled to death in the competition for copies. The present reviewer has, *fortunately*, more modest and more humane ambitions in presenting the following notes on a score of the books which have crossed his desk in the past year.

Those who are interested in the history of meteorology, especially in the United States, will find **Professor Abbe and the Isobars: The Story of Cleveland Abbe, America's First Weatherman** by **Truman Abbe** (Vantage Press, N. Y., 1955. 259 p. $3.50) one of the most satisfactory books of this type ever written. The author, one of Abbe's sons, was a physician and an early user of radium in the treatment for cancer in America. He tells a great deal of the adventurous life and the human aspects of the many-sided man who, though known when not yet 30 years of age as "Old Probs," directed the evolutionary course of the U. S. Signal Service and later the U. S. Weather Bureau, so that within ten years it ranked at the top of the meteorological services of the world and maintained that position as long as Abbe lived.

Cleveland Abbe was trained as an astronomer at the great Pul'kova Observatory near St. Petersburg, Russia, in the 1860's, where he acquired a passionate interest in the problems of research and a thorough acquaintance with the world's great astronomer-geophysicists of that day. From the rich resources of scientific literature in the vast and well-cataloged observatory library, he achieved at an early age a perspective which is altogether lacking in many who rise to the influential position that Cleveland Abbe maintained for most of his 45 years in the United States weather services. An example of his rare insight into nature and uncanny perspective comes to light in an article on the Magellanic Clouds in a recent issue of the *Scientific American:* Abbe was the first to perceive that this cluster of stars visible to the naked eye in the Southern Hemisphere was an entire galaxy similar to, but outside of, our Milky Way galaxy. This was forty years before astronomers in the early 1920's came to recognize that there were other galaxies than ours.

Abbe wrote the first and best (to date) textbook on agricultural meteorology in the English language, and in an 1890 textbook on meteorology was the first to include a chapter on turbulence—today standard material in a dynamic meteorology textbook. He also wrote the first, and until recently the only, textbook on meteorological instruments in English. He established the *Monthly Weather Review* and was editor at the time of its greatest fame. He started the first and greatest attempt at an international meteorological bibliography in the 1880's. Though several men worked for years to compile an almost exhaustive file of over 60,000 references (patiently checked and indexed by subjects), Congress for 20 years refused to appropriate funds for printing so that the fund of information might be made available to research workers throughout the world.

Abbe was a very kindly and human man, one who was loved by nearly everyone here and abroad, a man with courage to attempt the impossible (such as forecasting weather and making daily synoptic charts with only a

dozen or so telegraphic reports), yet modest enough to admit that his predictions were only "probabilities"; time after time he was defeated in attaining his scientific objectives through physical weakness or chance misfortune. Though never achieving the rank of Chief of either the Signal Service or the Weather Bureau, for years he was the highest paid man in the service. He survived political and beaucractic "knifing" and tragedy, yet maintained a firm belief in the essential equality and goodness of all men on earth.

In short, a lover of books and people, Cleveland Abbe was a man we all want to know and remember. We are grateful to his son (who died before the book came off the press) for preserving so much from his personal correspondence and diaries as well as from his friends and family.

Those who have enjoyed the many graphic books on the weather by Eric Sloane, such as *Clouds, Air and Wind, Skies and the Artist, Eric Sloane's Weather Book,* etc., will welcome his latest **Almanac and Weather Forecaster** with 104 illustrations by the author (Little, Brown and Co., Boston, 1955. 169 p. $3.50). The author has followed the style of the old farmer's almanacs, except for a brief, pictorial, introduction which explains the elementary principles of weather forecasting from clouds and local indications. The week-by-week account of the weather which the author experienced during the past year in rural New England is in a literary style which could be enjoyed at one sitting, or even more if read from week to week as the seasons unroll. Whether a person is experiencing New England weather first-hand, or vicariously from some more tropical clime, or merely as a memory of earlier years spent in the parts of the world where "10 months of the year are winter," this book and its lively illustrations will satisfy the hunger for the poetic-prose of philosopher-scientists (like Thoreau) who provide information (on such subjects as thunderstorms, hurricanes, air masses, cyclonic storms, frosts, halos, spring awakening and autumn colors, fishing and planting weather), as well as entertainment.

A simple but well edited and attractive book: **Weather Inference for Beginners, Made Clear in a Series of Actual Examples,** by **D. J. Holland** (Cambridge Univ. Press, 1953. 194 p. $6.00) goes into codes, weather types, thermodynamics of the atmosphere, fog, thunderstorms, visibility, convection, stability, radiation, air masses, winds, synoptic charts, cyclogenesis, upper winds and their forecasting, etc. Although the book starts out easy, and appears to be one that anyone can master, it soon gets into the basic equations and graphical methods of analysis used by a forecaster. Another book of this type, **Understanding the Weather, A Revision of Knowing the Weather** by **T. Morris Longstreth** (Macmillan Co., New York, 1953. 118 p. $2.50) takes up all the aspects of meteorology that any standard textbook treats and touches on climate and amateur observing and forecasting, along with chapters on "man-induced rain," snow, and hurricanes.

Our American Weather by **George H. T. Kimble** (McGraw-Hill, New York, 1955. 322 p. Price $4.75) takes up the weather of the United States and Canada month-by-month, instead of week-by-week as Eric Sloane's *Almanac* does. Variety, rather than average conditions, is emphasized, and only the outstanding features of the weather in any given month or season are discussed. Unusual subjects such as wind-chill, chinooks, snow-rollers, blizzards, singularities, flash floods, snow in summer, Arctic heat waves, the year without a summer, Indian summer, smog, and flying saucers are explained in their proper season. Charts are included to show the distribution of elements in the United States.

MICROMETEOROLOGY AND PLANT CLIMATE

Four excellent books on microclimatology or micrometeorology should prove useful to the gardener. **Climates in Miniature: A Study of Microclimate and Environment** by **T. Bedford Franklin** (Philosophical Library, Faber and Faber, London, 1955. 137 p. $3.75) deals with homely aspects of microclimate such as could be appreciated and measured by an amateur in his own garden: the temperatures in rabbit warrens, hedges, orchards, cranberry bogs, and field or garden crops; artificial methods of changing the microclimate (greenhouses, cold frames, caps, artificial heating of orchards or gardens); and

the physical processes involved in the formation of the microclimates (soil moisture, earth temperatures, dew ponds, solar and terrestrial radiation). All of the information in this readable book was gained by the author through years of personal experiments.

A more technical book on microclimate is the second edition of **Atmospheric Turbulence** by **Sir Oliver Graham Sutton** (John Wiley, New York, 1955. 111 p. $1.75). This pocket size text by the present director of the British Meteorological Service has now become a classic, so a second edition, bringing the rapidly changing subject up-to-date, is welcome. It deals with turbulence in general, the meteorology of the lower atmosphere, early theories, diffusion, eddies, and applications; with enough theory so that anyone can work out numerical problems if he desires. A similar, highly condensed, pocket-size book is **Humidity** by **H. L. Penman** (The Institute of Physics, Monographs for Students, London, 1955. 71 p. Five shillings). All weather observers and students, and most cooperative observers are acquainted with the sling psychrometer, which operates on the principle of the wet- and dry-bulb thermometer. Few realize the large number of other devices that are used to measure humidity. This book takes up systematically the various types of hygrometers, psychrometers, or humidity measuring devices. These fall into two types: those which measure the *weight* of the water and those which measure the *volume* of the water in the air. Some of the types considered are: the dew-point hygrometer; the frost-point hygrometer; the hair hygrometer; the electrolytic hygrometer; the thermal, the paper, the sulphuric acid, the diffusion, the anodized aluminum, the dielectric, the solid hygroscopic salt hygrometer; cobalt salt papers, gold-beater's skin; and the hygrometers invented by Daniell, Dunmore, Gregory, Regnault, and others; and the Dew-cell hygrometer, as well as the old standby the sling psychrometer. The principles, design, performance, installation, and operation of hygrometric equipment, are treated by a man who, at the oldest agricultural experiment station in the world (at Rothamsted, England), has a world-wide reputation for his work in micrometeorology of plants.

Plant Climate and Irrigation, edited by **Sidney A. Searle** (Chichester Press, Ltd., Chichester, England, 1954. 154 p. 20 s) is a collection of articles on agricultural, or rather horticultural, meteorology by the editor and several companion authors. The microclimate of plants in fields and greenhouses are discussed including soil moisture measurement, and requirements with special reference to tomato growing, effects of sunshine, temperature length of day, light intensity, heat and moisture balance, and experimental methods aimed at teaching the grower how to raise the best plants in the right way at the right time to get the maximum possible yield.

WEATHER CONTROL AND FORECASTING

Anyone interested in cloud seeding, weather control, or, as some say, "rain-making," should have a copy of **Further Outlook** by **F. H. Ludlam and R. S. Scorer,** with an introduction by Sir David Brunt, Secretary of the Royal Society (Allan Wingate, London, 1954. 174 p. $3.25). Although it takes up observing the weather, the processes of the atmosphere, forecasting as an art and as a science, the turbulent nature of the atmosphere, machine forecasting, etc., the two most interesting chapters are those on "Exploiting the Atmosphere," which deals with soaring, both on updrafts near hills and updrafts formed by convective clouds, wave clouds, frontal clouds, or merely pure thermals; and on "Weather Control," which takes up control of temperature, atmospheric pollution, fog, crop climates, and, most important of all, the science and art of cloud seeding and its possibilities and limitations as of this date.

POPULAR BOOKS

A nicely bound, edited, and illustrated book for the amateur weather observer is **Weathercasting** by **Charles and Ruth Laird** (Prentice-Hall, Inc., Englewood Cliffs, N. J., 1955. 163 p. $3.95). The basic principles of observing, forecasting, and the construction of weather instruments are covered in four well-written chapters. Details of the instruments and necessary equipment are shown in line drawings, sample forms for recording observations are provided; conversion, coding, and

decoding tables are included and a very detailed index appended.

Another book for the amateur: **The Weather Eye: An Irreverent Discourse upon Meteorological Lore, Ancient and Modern, with Many Indiscreet References to the Art of Forecasting as now Practised** by **C. R. Benstead** (R. Hale, Ltd., London, 3rd ed., 1954. 190 p. illustr. $3.00), deals with weather lore and official forecasts; and with the barometer, clouds, rainbows, air masses, thunderstorms, local winds, the aurora, and with man's feeble attempts to control it or to predict its shenanigans.

Two popular books have appeared recently which are almost identical in scope. **Young People's Book of Weather** by **David Holmes and Marvin Pitkin** (The McBride Company, New York, 1955. 179 p. $2.95) takes up in a dramatic way the various processes involved in the weather such as sun, clouds, circulation, cyclones, hurricanes, weather observers, forecasters, local or amateur forecasting, radar storm detection, and weather modification. **On the Wings of the Wind** by **David Holmes and Marvin Pitkin** (The McBride Company, New York, 1955. 204 p. $3.75) contains most of the chapters found in the above described book, but gives some of the more technical aspects of meteorology in chapters 4, 11, and 12, which discuss fronts and associated weather; the ionosphere, aurora and geomagnetic storms; the rocket and other high altitude observations of the Earth's atmosphere, respectively. While both books are non-technical, they contain considerable technical information in a palatable form.

A timely translation from the French is **Man and the Winds** by **E. Aubert de la Rue** (London, 1955. 206 p. 18s). Written in popular style, it contains a great deal of information on local winds, hurricanes, chinooks, erosion by winds, dunes, effect of winds on shipping, aviation, housing, climate, etc.; also on the effect of forests and shelter belts, and the transportation of sand and snow by wind; and a discussion of the physiological effects of wind and energy from wind.

And speaking of the effects of wind, a popular account of a shipping disaster accompanying the memorable storm of 31 January–1 February 1953 is found in **The Great Storm. Being the authentic story of the loss at sea of the "Princess Victoria" and other vessels early in 1953** by **J. Lennox Kerr** (G. C. Harrap, London, 1954. 213 p. $2.65). This graphic account of the storm and the attempts to rescue ships that foundered around the British Isles during that fateful night makes one aware how man is still at the mercy of the elements as in the days of neolithic man.

Our Changing Weather by **Carroll Lane Fenton and Mildred Adams Fenton** (Doubleday, Garden City, N. Y., 1954. 110 p. $2.50) is a beautifully illustrated book for the beginner or amateur, telling what makes the weather, how the seasons, winds, clouds, fog, rain, snow, dew, frost, air masses, fronts, cyclones, etc., behave.

Oklahoma Tornado

(*Continued from page 97*)

Vegetation in the storm track was wilted; some of it looked burned or scalded. This did not grow during the summer and died early in the fall. The first time I noticed the wilted vegetation, I thought the damage was done by the high winds and the debris in the air that had whipped it so badly. But after looking closely, I could see that in the ravines, behind the river banks in places that were protected from the wind the vegetation there too was wilted. It looked like a July hot wind hitting a corn patch in full tassel which turns it white.

The tornado dried the ground in the direct path only. It also dug holes along E Street where it passed. On the southern end of the street a strip of brick paving 50 feet wide and about 75 to 100 feet long was blown out, concrete base and all. On the north end of E Street there was a crater dug in the black top paving about half the size of the other hole. Two-thirds of the people were killed between these two holes.

Weatherwatch

Snowy Northeast—Droughty Southwest

DAVID M. LUDLUM, *Editor*

The late winter-early spring period of 1956 was marked by the usual contrasting weather conditions across the nation. In the Northeast many cities experienced their heaviest March snowfall and deepest March snow cover since records were commenced, and the snowy regime continued well into April. In the lower Missouri Valley, southern Plains, and the Southwest, the complaints were about the lack of moisture; the winter months rainfall in these agricultural areas approached record low amounts, and ominous dust storms (some of which were considered worse than any of the 1930's) raised fears of another dust bowl year. Drought also threatened the rich truck crop areas of Florida and interior California as March progressed.

In general, spring was very cool from the Great Plains eastward to the Atlantic seaboard. In New England and the Upper Lakes it was especially backward, and the planting season was considered two to three weeks behind schedule. Some frost damage was reported from widely separated areas across the country, but no major freeze took place such as occurred in March 1955. A number of stations reported their lowest temperatures of record for so late in the season during late March.

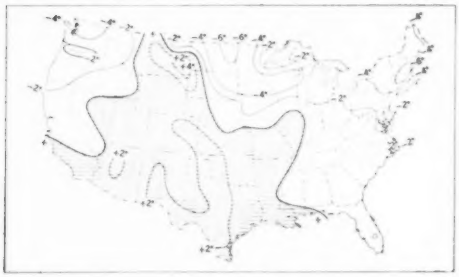
MARCH CIRCULATION—The key feature of the pressure distribution at upper levels over the Northern Hemisphere was a deep polar vortex situated very close to the North Pole. This marked a distinct change from the regime which had existed without break since late October 1955. Low pressure in the polar regions is usually indicative of a high index of westerly flow over mid-latitudes. After being at a low ebb for several consecutive months, the westerlies became active in late February, and weather systems, in the absence of blocking, began moving at a faster clip around the globe.

Pressure at upper levels averaged below normal throughout Canada and the adjacent Arctic during the early part of March as the polar vortex dominated. Conversely, a large high pressure area built up to the west over the tundras of northern Siberia, establishing a flow pattern of very cold air over western Canada and Alaska, where record March minimum temperatures were set during the first days of March. This reservoir of cold air in Canada remained a factor in the weather picture throughout the spring and contributed a major ingredient to the cold, snowy period in the Northeast.

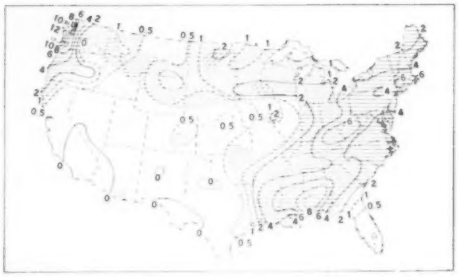
Over the United States in March the pressure systems showed an extensive ridge of high pressure running from British Columbia southward along the coast. The next pressure feature to the east was a deep trough just off the Atlantic Coast. Thus, there was a clear path for northwesterlies from western Canada to sweep the breadth of the continent and to bring below normal temperatures to all except the northwestern sections of the country.

As the month progressed, the pressure pattern underwent some evolutionary changes. The unusually long distance between ridge and trough in the United States was considerably shortened by the continued development and eastward movement of the western ridge to a position over the Plateau. At the same time a blocking ridge built up in the mid-Atlantic, putting the trough off the Atlantic Coast in a squeeze from which important weather events developed. The western ridge supplied cold air on the western side of the trough; the mid-Atlantic ridge brought

MONTH OF MARCH 1956



Departure of Average Temperature from Normal in degrees Fahrenheit. USWB chart.



Total Precipitation in inches. USWB chart.

warm, moist air northward in its return circulation on the eastern side of the trough. Disturbances that formed along the meeting zone of these contrasting air masses were forced to move with a major northerly component close to the coastline. Thus, the Middle Atlantic States and New England were swept by a series of northeast snow storms that will long be remembered by weather followers.

The main area of cyclogenesis was in the lee of the Rocky Mountains with a tendency for storm centers to move southeastward and then eastward to the Atlantic Coast. The main track favored by most storms crossed Kansas, Missouri, the Ohio Valley, and then off the coast in the Maryland-Virginia area. Only two followed the usual St. Lawrence Valley track during the entire month. There was a marked regeneration of the storm centers when they moved into the deep trough existing off the East Coast. In addition to the above, three storms generated in the lower Mississippi Valley and moved directly northeastward at very fast paces. The Pacific States were almost devoid of cyclonic activity; only in the last week did any major disturbances penetrate the coastline and these crossed well to the north in British Columbia.

APRIL CIRCULATION—The general regime which marked the latter part of March continued into April. The polar vortex, so outstanding in March, lost some of its strength and gradually migrated to a position over northwest Canada where a center of below normal pressure appeared on the mean April upper-air map, at about 70° N. rather than at 90° N. as in March. The major development of the period was the building of the mid-Atlantic ridge northwestward over Greenland and northeastern Canada. Thus, another blocking situation was established in much the same location as the blocking ridges which had been the major features of the weather maps of 1955 and early 1956. This meant a return to a weak westerly circulation and much north and south transport of air masses to give parts of the United States another treat to abnormal temperature and moisture conditions.

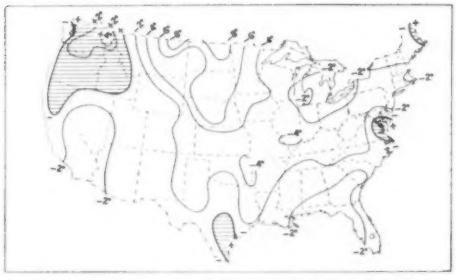
The principal trough over North America extended southeastward from the Arctic low in northwest Canada, over Hudson Bay, to Maine, and then southward not far off the Atlantic Coast to central Cuba. The southern portion of the trough was in much the same position as it had been in the previous month of our period. Pressure aloft was below normal over all the United States except in the extreme Northwest. A strengthening ridge off the Pacific Coast States and British Columbia served as another block to the usual west to east air flow across the eastern Pacific.

The strong western ridge-eastern trough situation continued to bring a northwesterly flow of cold air from Canada into the United States. Temperatures were much below normal in the northern Plains in April and below normal everywhere except in the Northwest which was under the anticyclonic protection of the ridge. The cold delayed planting from two to three weeks in the corn and wheat belts, and April snows in the northern border states hampered the progress of farm work.

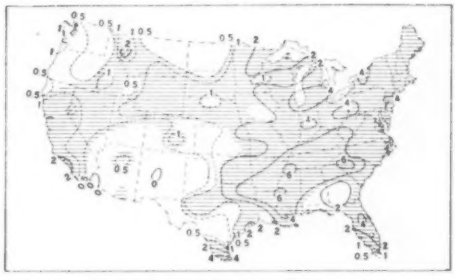
The Atlantic trough was the center of storm activity during the month. Cyclogenesis was active in the Virginia-Carolina area; most storm tracks had a good northerly component, reflecting the blocking conditions in the North Atlantic to the east and northeast. The most annoying of all the April lows for Eastern forecasters failed to follow the pattern that had developed in late March and early April. A small depression developed in east Texas on the 9th, and then looped southward into the Gulf of Mexico, crossed the northern part of the Florida peninsula, and came inshore in South Carolina where it packed winds up to 60 mph. It turned a complete small circle in central South Carolina before heading northeastward for Cape Hatteras as an apparently dangerous storm. At this time forecasters were on the alert for another snow situation along the Middle Atlantic and New England seaboard. The storm center, however, turned southeastward from Hatteras and on the 12th was well out to sea, heading easterly away from the mainland.

Again there was cyclogenesis in the central Plateau and Rocky Mountain area with a rather erratic movement of these centers. Only one favored a regular track up the St. Lawrence Valley, and this was near the close of the month. No centers crossed the Pacific Coast within the United States, and the tracks from the Pacific were generally well to the north over the Alaskan panhandle into northwest Canada.

MONTH OF APRIL 1956



Departure of Average Temperature from Normal in degrees Fahrenheit. USWB chart.



Total Precipitation in inches. USWB chart.

NORTHEAST SNOWS—Six major snow storms hit the Northeastern States in March. Down East at Portland, Maine, a sector famous for late season storms, it was the snowiest March since Weather Bureau records were commenced in 1871. At Blue Hill Observatory near Boston since 1885 and at Hartford, Connecticut, since 1904, there have not been equally snowy months since records began. Boston, itself, had its second snowiest March since 1871. From New Jersey northeastward it will be a March that will long be remembered to take its place with other famous snowy springs such as 1772, 1785, 1799, 1807, 1819, 1843, 1896, and 1916 when deep snows occurred very late in the season.

The first two snow storms of March were confined mainly to northern New England. On the 8–9th a low moved northeastward from the Southwest and at 0130 EST on the 8th was centered near Lake Ontario; a secondary, which formed off the New Jersey coast, moved northeastward close to the shoreline, dropping 8.6″ at Portland, Maine, and 10.6″ at Caribou—this was the heaviest fall of the month at the latter.

The next general snow occurred on the 13–14th; again a low moved very rapidly from central Kentucky to a position off Cape Cod by the afternoon of the 14th. Snow was general throughout New England with the heaviest amounts reported in a belt across the central part of the area from northwest Connecticut to the southern coast of Maine: Pittsfield 6.5″, Concord 4.6″ and Portland 6.0″.

Cyclonic activity was marked on the weather maps for the next week. Storms developed quickly and moved very rapidly. Late on the 15th a large precipitation area spread over the Gulf States with a low center in Mississippi at 0130 on the 16th. Twenty-four hours later the center was off the Nova Scotia coast, having moved offshore in southern Maryland and then skirted Cape Cod in its rush northeastward. An 18-hour fall of dry snow dumped 12.9″ at Blue Hill with equal amounts general throughout southern and central New England. This speedy storm deepened considerably in its passage up the coast on St. Patrick's Day eve; as northeast gales developed, near blizzard conditions completely disrupted traffic and business. It was classified as equal in violence to the Valentine Day's storm of 1940, previously judged the severest northeast snow storm in Boston of this generation.

A second major storm followed closely on the heels of that of the 16–17th. This center, however, originated in another sector, the Northwest, and moved at a normal pace southeastward as an innocent looking low during the 17th and 18th to a position in southern Virginia. Here it began to pick up moisture from the Atlantic Ocean and a remarkable regeneration took place. Snow broke out in southern Pennsylvania and West Virginia eastward to the coast. The center turned northward from Virginia, deepened considerably, but did not move very rapidly. Indeed, it appeared to become almost stationary when just south of Cape Cod, permitting the whirl of moist northeast winds to continue. A heavy snow belt developed from northern New Jersey and stretched northeastward to the Massachusetts coast. Newark, New Jersey, measured 17.6″ in 24 hours on the 18–19th, New York City 13.2″, Hartford 14.0″, Blue Hill 19.5″, and Boston 13.3″. These were the heaviest snows in this area since the memorable storms of 1947 and 1948.

After a brief respite, a second low moved eastward from the Middle West, this time crossing the New Jersey coast before turning northeastward. Though the Middle Atlantic states received only light falls, New England again had substantial amounts: Hartford 6.8″ and Blue Hill 12.3″. This storm extended further north than its predecessor and gave southern Maine another deep cover. A final storm completed the month's activity as a low on the 29–30th moved eastward from Kansas to the coast of Maryland before making its recurve to the northeast. Heavy falls were concentrated in southeastern Maine where Portland received 5.6″ more. Temperatures in southern New England were at or above freezing, so new accumulations were not great despite the large amount of moisture available.

SOUTHWEST DROUGHTS—In December and January the Pacific Coast states were making headlines with accounts of excessive rains and devastating floods. After a very wet winter, the first spring month proved one of the driest in California's history. In fact, at Sacramento March of 1956 was the driest since weather records were commenced in 1850—only 0.03″ were recorded. At San Francisco it was the third driest March. The dry area extended eastward to the Rocky Mountains and beyond. Utah had not only the driest March, but many stations also reported new all-time maximum daily temperatures.

In the far Southwest the beginnings of a serious drought appeared. Rainfall at San Diego from 1 July to 31 March amounted to only 2.86 inches, the lowest winter total since records were started. Las Vegas, Nevada, had no measurable precipitation in either February or March.

Farther east in the southern Plains and lower Missouri Valley an increasingly dry area made its appearance as the winter progressed. Heavy October rains had facilitated autumn planting of the crops, but by 1 April, with the spring planting season imminent, the situation appeared serious. From October to April much of the area received less than 50% of normal rainfall, and much of the old Dust Bowl area has less than 25%. Reports of blowing dust were frequent with some February storms in west Texas reported as more serious than those of the 1930's.

Early April brought some rain and snow to a strip from Oklahoma to Nebraska. But it was not until the last week of April that sufficient moisture soaked most of the drought-threatened area. The great corn states of Iowa, Missouri, and Illinois welcomed rains up to 2.00″ on 28–30 April. Further rains in early May pushed the dry frontier into extreme western Texas, and even this perennial drought area received general rains at the end of May.

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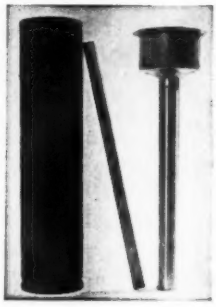

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Numerical Unit (*Continued from page 79*)

atmospheric models needed to be observed and evaluated over an extended period. This period of observation and testing has occupied the first year of operation. At present several improvements and refinements to increase the accuracy of the daily forecast charts are being readied for incorporation into the present operational models, and the forecast area will soon be expanded to cover most of the Northern Hemisphere.

The processing of weather data will soon be largely handled by machine methods. First, the messages will be taken off the teletype circuits on punched tapes. After the weather data not needed in machine forecasting has been cut out, the remaining information will be punched automatically on IBM cards using a tape-to-card converter. The resulting stack of cards will then be fed into the computer which can select, check, and store in its memory the weather data for several levels in the atmosphere. Second, the computer will draw (analyze) a weather chart at each of the several levels in the atmosphere required by the model being used to make a numerical weather forecast. The third step involved will be the actual machine forecasting of a weather chart using the input analyses obtained in step two above.

This three-step machine method of processing meteorological data must be constantly watched and checked by trained weather analysts. They must feed supplemental weather data to the machine to allow it to complete its analyses over ocean areas where actual observations are few and widely scattered, particularly in the upper atmosphere. The machine forecast charts must be studied and interpreted by trained meteorologists who issue forecasts of wind, temperature, and precipitation to the military services and to the general public. It is expected, therefore, that machine methods of weather analysis and forecasting will eventually take over some of the chores now performed by the meteorologist. Indeed, the weatherman will be relieved of much detailed and time-consuming data processing and can concentrate on studying the weather and putting out a detailed forecast which, after all, is the most important part of his work.

Bench-Mark (*Continued from page 89*)

man-made influences upon the climate of a non-local nature, such as air pollution. A relatively small number of well-selected and well-distributed stations will probably suffice for all these purposes. For the continental United States, Alaska, Hawaii, and Puerto Rico, about fifty such stations should be the right order of magnitude. These will then serve as a primary reference network for other Weather Bureau and cooperative stations. Wherever available, stations with reliable records over several decades in the past are being selected. As to the future fate of these localities we can now make only an educated guess, but it is not likely that National and State Parks or Agricultural Experiment Stations will be encroached upon by activities affecting climatic records.

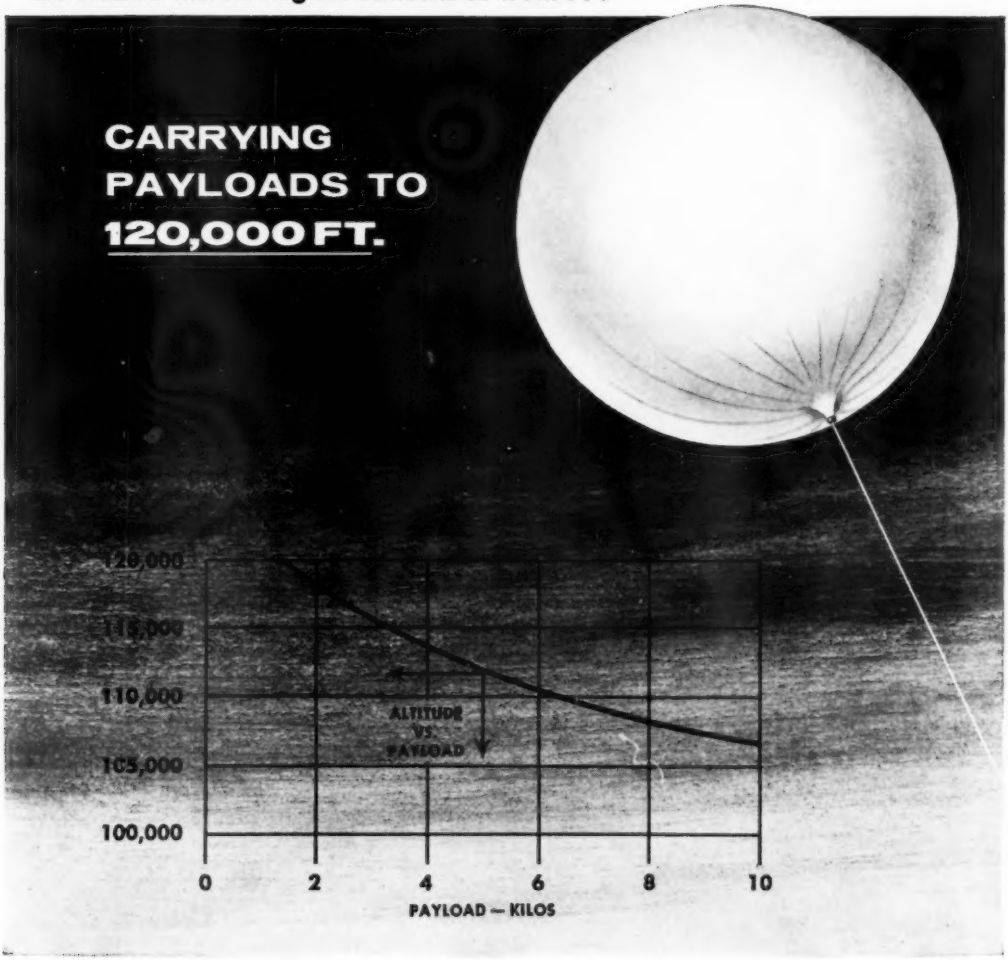
For the present, the selected stations will continue as temperature and precipitation stations only. The Weather Bureau hopes to equip these stations in the long run with autographic instruments in order to insure against accidental losses of observations. In time, also, plans call for installation of wind and evaporation equipment at some of the stations and, at a few, instruments for recording solar radiation, soil moisture and soil temperature, humidity, with possibly electric conductivity, radioactivity, and air pollution.

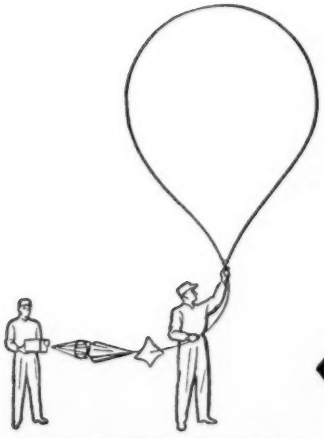
Selection of these climatological benchmark stations is not yet completed. Twenty-six sites have been tentatively chosen as shown on the accompanying chart. Complete analysis of their past records for homogeneity is yet necessary and has been started.

Back Issues Wanted

The following rare issues of *Weatherwise* are required to complete sets for binding: Vol. I–5, October 1948 (Brookhaven Tower on blue cover), and Vol. IV–6, December 1951 (Sky Hook Balloon on red cover). The editor will pay $1.00 each for copies of the above—address Box 216, Princeton, N. J.

DAREX meteorological balloons at work . . .





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